Testimony before the U.S.-China Economic and Security Review Commission

Hearing on

China's Energy Consumption and Opportunities for U.S.-China Cooperation to Address the Effects of China's Energy Use

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Members of the Commission, it is an honor to appear before you today.

I direct the research group on Energy Technology Innovation Policy at Harvard University's John F. Kennedy School of Government in the Belfer Center for Science & International Affairs. We aim to analyze, inform, and shape energy policy in the United States, China, and India, and we particularly focus on how to accelerate the development and deployment of advanced and cleaner energy technologies in these three countries. We have a number of current research projects in China in collaboration with Chinese partners including the China Automotive Technology & Research Center and the Chinese Academy of Sciences Institute of Thermoengineering Physics. Much of my own research since 1998 has been on energy and transportation in China.

The main points that I would like to make to you are as follows:

- Significantly enhanced cooperation between the United States and China on energy matters is highly desirable on both energy security and environmental grounds. The two highest priorities for enhanced cooperation should be energy efficiency across all sectors, and low-carbon coal technologies for power and industrial use.
- Foreign direct investment (FDI) can be an effective mechanism for the transfer of technologies, but it does not automatically bring energy efficient or clean technologies to the recipient country.
- FDI must be combined with a policy-incentive framework in order to provoke cleaner and more energy-efficient technologies to be transferred.
- Both the Chinese government and the U.S. government can establish elements of this policy framework, and one could also be created at a multinational level.
- In China, we have seen remarkable technological leapfrogging in some cases, and a distinct lack of leapfrogging in other cases. Where it occurs, the lack of leapfrogging can be attributed to lagging Chinese technological capabilities and/or the absence of incentive policies.

Introduction

The economic and national security of the United States is now inextricably connected to China's energy consumption with respect to the environment, oil and gas security, and the economy.

Environmentally, Chinese energy consumption is already affecting the United States. Chinese air pollutants have been tracked and detected on the west coast of the United States. Indirectly, Chinese emissions of greenhouse gases are a growing source of climate disruption, although most of the greenhouse gases

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cumulatively built up in the atmosphere until now came from industrialized countries. Going forward, however, it is clear that China will be a top emitter of greenhouse gases along with the United States.

China is emerging as a major consumer of oil, and there is strong potential for China to become a major natural gas consumer as well, especially if it tries to reduce its greenhouse-gas emissions. China became a net importer of oil in the mid-1990s, and is now the second-largest consumer of oil, and the third-largest oil importer in the world. About half of China's imports come from the Middle East, but Angola became the largest supplier last year, and indeed, China has invested heavily in energy resources in Africa. Although there have been a few new oil discoveries in China recently, Chinese reserves are on the decline. China has relatively few natural gas reserves domestically, and therefore uses virtually no natural gas in its power sector at this time. If China decides to increase its reliance on natural gas, China will likely import natural gas through LNG import terminals or by pipeline from central Asia or Russia. If China begins to import large quantities of natural gas from the Perisan Gulf and Russia, this could have serious geo-political implications.

Economically, China's growing energy consumption presents both challenge and opportunity. The challenge is that as China imports greater amounts of energy, prices of these commodities could rise until supply catches up, and price spikes will be especially likely during supply disruption events. On the opportunity side, the Chinese energy sector is already large and growing rapidly so it represents an exciting market opportunity for U.S. energy companies. In 2006 alone, China installed 101 GW of new coal-fired power, 90 GW of which was coal-fired power. To put that astounding number in perspective, India's entire electricity system is 131 GW (2004 data).[2] In 2006, power generation equipment was the second-largest U.S. export to China, but unfortunately, U.S. exports represented only 4 percent of Chinese power generation equipment imports.[3] U.S. firms are not penetrating the Chinese market as much as other foreign firms. As China moves to upgrade its energy system, it will likely need to import more advanced energy technologies, and the United States should be positioning itself to be a much larger technology provider to China than it currently is in the energy sector.

From the standpoint of U.S. national interests, there are numerous policies that would be desirable for the Chinese government to adopt, such as more stringent passenger-car fuel-efficiency standards to dampen the Chinese demand for oil, a carbon tax to reduce greenhouse gas emissions, or more aggressive energy intensity reduction policies to reduce energy consumption and harmful air pollutants. It will be difficult, however, to persuade China to accept such policies if the United States has not itself adopted them.

The Challenges

China's energy-related challenges are many, including the need for energy to sustain economic growth, its rapidly increasing foreign dependency for oil and gas, the need to provide modern forms of energy to China's rural poor, the increasingly severe urban air pollution, the massive acid deposition across most of China's land area, growing concerns about global climate change and the need to rapidly reduce greenhouse-gas emissions, and access to advanced energy technologies to address all of the above challenges.

China's long-term energy security is not only dependent on having sufficient supplies of energy to sustain its incredible rate of economic growth, but it will be equally dependent on its ability to manage the growth in energy demand without causing intolerable environmental damage.

Only with the development and deployment of improved energy technologies can China achieve its targets for development and economic growth while avoiding energy conflicts and global climate change. The big questions, therefore, are:

1. How will China acquire those advanced energy technologies?

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[2] Energy Information Administration, India Country Analysis Brief, U.S. Department of Energy, Washington, DC, January 2007.

[3] U.S. China Business Council, "US-China Trade Statistics," downloaded from http://www.uschina.org/statistics/tradetable.html.

2. Will China (and the United States) deploy advanced and cleaner technologies in time to prevent climate change and conflict over energy resources and resulting economic disruption?
3. What are the win-win policies that allow the United States to reap benefits from being a technology provider to China and also allow China to deploy advanced energy technologies more quickly.

The Chinese Context

The United States and China are now the two largest energy producers and consumers in the world. China presently consumes two-thirds as much commercial energy as the United States does, consumes one-third as much oil as the United States does, imports one-third as much oil as the United States (although China's oil import growth rate has been much faster in recent years); uses two-thirds as much electricity as the United States does; consumes almost twice as much coal on a per-ton basis as the United States; and has only 13% of the world's coal reserves compared with 27% for the United States.

Unlike in the United States, coal absolutely dominates the energy picture in China. Coal accounts for three-quarters of commercial energy supply in China and it also accounts for approximately 80% of China's CO_2 emissions.[4] In 2006, China reportedly consumed 2.2 billion tones of coal, mostly in power plants and industry.

So far, the transportation sector is not a big consumer of energy in China, accounting for only 8 percent overall.[5] China's new fuel-efficiency standards and fiscal policies for fuel consumption for passenger cars will help to avoid a big increase in oil consumption there, but given the huge potential market for automobiles there, the fuel efficiency standards will need to be further strengthened and complimented by measures to reduce the demand for automobiles and fuel consumption if China is to avoid becoming the biggest oil-consuming country in the world.

According to the latest official data available, China currently emits about 15% of the world's total carbon dioxide emissions from fossil fuel burning, as compared with 22% in the United States. China's per-capita emissions are one-sixth that of the United States. So, currently, the United States is the largest emitter in the world in both aggregate and per capita terms, but China is catching up quickly in terms of aggregate emissions. The International Energy Agency's *World Energy Outlook 2006* projects that China's greenhouse gas emissions will surpass the United States in 2009, and a subsequent report has indicated that China's emissions may surpass those of the United States as early as this year. Most of China's emissions come from the industrial and electricity sectors. As of 2000, electricity accounted for 52% of CO_2 emissions (and 75% of China's electricity is consumed by industry[6]), cement accounts for 28%, iron and steel for 9%, and transportation for 8%.[7]

The Role of Foreign Direct Investment

As I documented in my recent book, China Shifts Gears: Automakers, Oil, Pollution, and Development[8], (The MIT Press, 2006), foreign direct investment can be a highly effective mechanism for the transfer of technology, but technology transfer (especially clean technology transfer), does not happen automatically. With respect to the automobile industry, I found that there was very little clean technology transfer for many years. There must be incentives in place to elicit clean technology transfer because the private companies do not find it in their interest to develop, transfer, and install cleaner technologies on their own. These incentives can take many forms, and the one that proved most effective in the case of the Chinese automobile industry was the establishment of emission standards for cars. Other incentives that could theoretically be effective include consumer demand in the recipient country for cleaner or more efficient technologies, requirements that cleaner or more efficient technologies be transferred in the private joint venture or

[4] Energy Information Administration, International Energy Outlook, U.S. Department of Energy, 2006.
[5] National Bureau of Statistics, Statistical Yearbook of China, Chapter 7: Energy, 2005.
[6] China Energy Database, Lawrence Berkeley National Laboratory.
[7] Center for Clean Air Policy, "Greenhouse Gas Mitigation in China," November 2006.
[8] MIT Press, 2006.

licensing agreements, concern about a company's image in failing to transfer clean technologies to a developing country, or an international agreement that established rules for foreign direct investment.

Before the Chinese government set its first emission standards for cars, which went into force in 2000, neither the Chinese domestic companies nor the foreign joint venture partners installed pollution control devices in the automobiles. But, as soon as the standards were promulgated, all the joint venture firms complied, which required the transfer of catalytic converter technology to China. With respect to fuel efficiency, the Chinese consumer has tended to demand fuel efficient cars because it generally cares about fuel costs more than the U.S. consumer. This consumer demand led to some design modifications for vehicle models being introduced into the Chinese market before there was a fuel-efficiency standard, but, again, it was not until 2005 when China's first fuel efficiency standards took effect that there were significant technological changes. Theoretically, the joint venture contracts could have provided a stronger incentive for cleaner technology transfer if the Chinese side of the automotive joint ventures had bargained harder for such technology, but they did not for a variety of reasons. Again, the lack of a policy framework on the part of the Chinese government prior to 2000 created a lack of incentive for technology transfer, and therefore a lack of leapfrogging to cleaner technologies in the automobile industry. Now that the Chinese government has passed more stringent pollution control standards, and scheduled even more stringent fuel efficiency standards that will take effect in 2008 for passenger cars, the Chinese auto industry is catching up quickly environmentally, and will likely leapfrog beyond where the United States currently is with respect to fuel-efficiency technology in the Chinese car fleet.

Beyond the automobile industry, we have seen a lack of leapfrogging in other major energy-consuming sectors. Most worrying from the standpoint of climate change is the power sector, dominated by coal, where more than half of China's power plants are smaller than 300 MW. In fact, there are more than 5,000 plants that are smaller than 100 MW (24% of total capacity), resulting in very poor energy efficiency and high emissions of SO_2, NO_x, and CO_2. There are a handful of supercritical plants, and the first ultra-supercritical pulverized coal plant came on line in November 2006 (Huaneng Group Yu-Huan plant). Thirty-four more ultra-supercritical plants are under construction.[9] Because of the strong imperative to provide sufficient electricity to keep the economy growing in the face of chronic electricity shortages, the Chinese have been building relatively inexpensive, inefficient, sub-critical power plants. The sub-critical plants are generally highly polluting in terms of SO_2 and NO_x, and they are also carbon-dioxide intensive. Pollution standards for SO_2 and NO_x have not been enforced well, so compliance has been poor. Also, these plants cannot be easily or cost-effectively retrofitted to capture and store carbon dioxide when and if China decides to control greenhouse gas emissions, so China is effectively locking into a high CO_2-emission future with each new plant that it builds of this kind. Again, the lack of an effective policy framework results in very weak incentives for Chinese and foreign firms alike to install more expensive pollution-control technologies.

For many years now, the Ministry of Science & Technology (MOST) in China has supported an aggressive research and development program for advanced coal technologies, and this is beginning to bear fruit with the new super-critical, ultra-supercritical, and coal-gasification polygeneration plants that are being demonstrated and deployed to a limited extent now. In general, the significantly higher cost of the more advanced, efficient power plant technologies from foreign companies have proven prohibitively expensive. The first planned integrated gasification combined cycle (IGCC) coal plant, for example, was halted due to the unexpectedly high costs of the foreign technology at the time. This problem motivated the Chinese government and electricity companies to redouble their efforts to produce their own indigenous technology, and now three IGCC plants using indigenous technology are planned for the current 5-year plan.

U.S.-China Energy Cooperation

I would recommend four priorities for enhancing U.S.-China energy cooperation to address the effects of China's energy use, and to encourage private-sector adoption of greater energy-efficiency and cleaner technologies.

[9] Lifeng ZHAO, "Progress and Development of Clean Coal Technology in China," Presentation at Energy Technology Innovation Project seminar, Harvard University, February 13, 2007.

First, as soon as the United States has established a domestic mandatory program to reduce greenhouse gases, the United States should ask China to adopt one as well, unique to its own circumstances. At the same time, the United States should consider forming a bilateral or multilateral investment fund to accelerate the deployment of low-carbon technologies in China. This fund could provide low or no-interest loans or direct grants for major new industrial facilities or power plants that utilize low-carbon technologies. Without policies in place that effectively require the use of low-carbon technologies (e.g. CO_2 performance standards or carbon taxes) or incentive programs that make the use of low-carbon technologies financially attractive (e.g. coal gasification loan guarantee program), the private sector will have no incentive to develop, transfer, and deploy low-carbon energy technologies in China. The establishment of concrete greenhouse-gas policies in both the United States and China is of the utmost urgency.

By using the cheapest technologies currently available, China is rapidly locking into high greenhouse-gas-emitting industrial facilities and power plants for decades. Coal use in China's industrial and electric power sectors is growing very rapidly, and many of the plants and facilities that are being built will last for multiple decades. The lifetime CO_2 emissions from the coal-fired power plants projected to be built worldwide in the next two decades will be equivalent to all the CO_2 emissions from coal-fired power plants from 1751-2000.[10] According to the reference case of the International Energy Agency's World Energy Outlook, 55% of the incremental coal-fired electricity generation between 2004-2030 will take place in China. CO_2 emissions from Chinese coal-fired power plants alone are expected to be 5450 MMT CO_2 in 2030, business as usual (equivalent to 13% of global emissions in that year.[11] Of course, construction of high- CO_2 emitting facilities is happening in the United States too, but at a slower rate. The rapid growth in energy-related plants and infrastructure in China is expected to continue during the next few years, so "leapfrogging" to lower-carbon technologies in the near term is absolutely critical. One cannot imagine that China will pre-maturely retire their new power plants or factories (just as the United States would not).

Second, there is much scope for enhanced energy-technology cooperation between the two countries. Joint research, development, and demonstration projects can be valuable for both countries, and they also can be a mechanism for bringing the U.S. private sector in contact with Chinese partners. While there has been ongoing technology cooperation between the U.S. Department of Energy and Chinese Ministry of Science and Technology through the protocols on fossil energy and energy efficiency and renewable energy, it has been inadequate and underfunded. High priority areas include research, development, and demonstration of carbon capture and storage, renewable energy, energy storage, and energy efficiency technologies.

Third, the United States government should negotiate a bilateral agreement with the Chinese on oil security. Since China is not a member of the International Energy Agency, but it is now one of the world's largest oil consumers, the United States should negotiate an agreement with China on oil reserve and stockpile data disclosure and the release of oil stockpiles in the event of an emergency.

Finally, and perhaps most difficult, the United States should significantly bolster its cooperative activities related to capacity building for energy and environmental data collection and reporting, policymaking, institution-building, and enforcement. As a developing country, China still lacks many of the necessary institutions, policies, and enforcement mechanisms that are needed to foster vibrant markets, technology transfer, and environmental protection. This is particularly the case at the provincial and county level in China.

[10] As calculated by David Hawkins, Natural Resources Defense Council.
[11] International Energy Agency, *World Energy Outlook 2006*, OECD/IEA, Paris, 2006.